3/3

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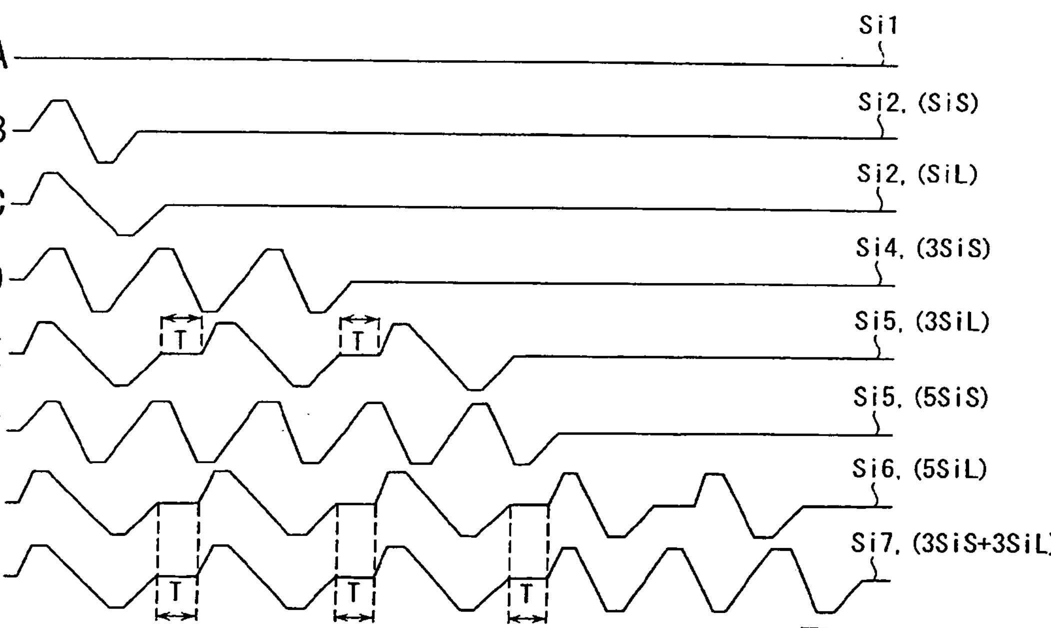
(54) Printer and printer head control method

(57) This invention relates to a printer (21) and a printer head (22) control method and relates in particular to a method applicable to ink jet printers for regulating the quantity of ink by diluting the ink with dilution fluid to express different print tones, reduce irregularities in supply of ink supplied to the dispensing nozzle compared to the related art, and to provide a high quality printing effect. This invention regulates the dilution fluid (K) for diluting the ink (I) by controlling the number of pulses.

FIG. 1A
FIG. 1B
FIG. 1C
FIG. 1D
FIG. 1E
FIG. 1F
FIG. 1G
FIG. 1H



EP 1 093 924 A1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a printer and printer head control method and relates in particular to a printer and printer head control method in ink jet printers for expressing various types of print tones by controlling the diluted ink with dilution fluid. This invention reduces irregularities in the quantity of ink supplied to the dispensing nozzle opening occurring in the related art and can deliver high quality printing by regulating the number of pulses to control the quantity of dilution fluid for diluting the ink.

Description of Related Art

[0002] Methods have been proposed in the related art for expressing various types of print tones in ink jet printers by controlling the quantity of ink dilution with dilution fluid.

[0003] A drawing of the cross section of one head for this type of ink jet printer along with the peripheral structure is shown in Fig. 8. In this drawing, a head 2 of an ink jet printer 1 is comprised of a nozzle plate 4, piezoelectric elements 5K and 5I constituting the drive element, and an oscillator plate 3 in an inner plate P.

[0004] Here, the inner plate P is formed for instance of plastic by injection molding and constitutes the walls of this head 2. The oscillator plate 3 is formed by a resilient plate shaped member such as a metallic plate. The nozzle plate 4 is formed by a plate shaped member such as metal plate forming a water-repellent coating on the surface.

[0005] The head 2 is supplied with dilution fluid K and ink I from the respective tanks by way of the supply paths LI and LK through the inner plate P. Buffer tanks 6I and 6K are formed at the base of these supply paths LI and LK and the head 2 stores the ink I and dilution fluid K supplied from the supply paths LI and LK, into these buffer tanks 6I and 6K.

[0006] The head 2 also supplies the ink I and dilution fluid K stored in the buffer tanks 6I and 6K to the respective pressure chambers 8I and 8K by way of the supply paths 7I and 7K formed in the nozzle plate 4.

[0007] The pressure chambers 8I and 8K are each formed adjoining the wall 9 and enclosed by the oscillator plate 3 and the nozzle plate 4. The piezoelectric elements 5I and 5K are respectively installed on the oscillator plate 3 for the pressure chambers 8I and 8K by way of the specified plates 10I and 10K. The drive action of the piezoelectric elements 5I and 5K are configured to apply contact pressure to the oscillator plate 3 so that changes can be made in the pressure applied to the ink I and the dilution fluid K held inside the pressure chambers 8I and 8K.

[0008] The nozzle plate 4 for the pressure chamber 8K on the dilution fluid side, is formed with a through hole extending towards the object for printing, and in contact with the pressure chamber 8I (ink side) and wall 9. The dispensing nozzle 11 is comprised by this through hole. This dispensing nozzle 11 is formed in a circular shape in the nozzle plate 4 as shown by the symbol A in the enlarged figure.

[0009] A through hole is formed extending diagonally towards the dispensing nozzle 11 side in the nozzle plate 4 on the ink side of the pressure chamber 8I. A fixed flow nozzle 12 is comprised by this through hole. This fixed flow nozzle 12 is formed by drilling a hole in a crescent shape in the nozzle plate 4 so as to separate the spray hole 12a by a specified distance r from the dispensing hole 11A of the dispensing nozzle 11.

[0010] In this way, the ink side piezoelectric element 5I is driven in the head 2 as shown in Fig. 9 and the ink I is pressed out from the fixed flow nozzle 12, and supplied to the dispensing outlet 11A of dispensing nozzle 11. The dilution fluid side piezoelectric element 5K is driven to make the dilution fluid K fly outwards from the dispensing nozzle 11, and along with diluting the ink I supplied from the dispensing outlet 11A of nozzle 11, the diluted ink I is made to fly towards the object for printing. In the head 2 at this time, the quantity of ink I supplied to the dispensing nozzle 11 side is regulated by driving the ink side piezoelectric element 5I, and various print tones can be expressed in the printing, by adjusting the concentration of the ink I flying towards the object for printing.

[0011] The head controller 16 in Fig. 8, generates the piezoelectric element 5I and 5K drive signals SI and SK according to print tone data DI output from the host controller.

[0012] The head controller 16 maintains the dilution ink drive signal SK at a fixed voltage V1K (Fig. 10B), and at a specified period T11 (for instance a 50 microsecond period) and generates an ink drive signal SI (Fig. 10A) to lower the print tone from the specified voltage V1I to a voltage V2I. The controller 16 in this way, emits from the fixed flow nozzle 12, a quantity of ink determined by the difference in electrical potential ΔV between voltage V1I and voltage V2I, and supplies the ink to the dispensing outlet 11a of dispensing nozzle 11.

[0013] Next, with the ink drive control signal SI maintained at voltage V21, the head controller 16 suddenly lowers the drive signal SK (for instance in a period (T1K) of 12 microseconds). The dilution fluid K is in this way made to fly outward from the dispensing nozzle 11, and along with diluting the ink I supplied to dispensing outlet 11a of dispensing nozzle 11, the diluted ink I is made to fly towards the object for printing.

[0014] After the ink drive signal SI and dilution fluid drive signal SK have been maintained at the lowered voltage for an interval (for instance a period of 50 microseconds) between specified time T2I and T2K, the head controller 16 raises the voltage back to the original volt-

age V1I and V1K for a sufficiently long time T3I and T3K (for instance a period of 100 microseconds) versus the lowered voltage time, and a printing cycle for one dot is in this way completed.

[0015] In an ink jet printer 1, multiheads are comprised of a plurality of heads of a structure configured so that a plurality of dots are simultaneously printed in parallel by this multihead to deliver improved printing speed.

[0016] However, in an ink jet printer that dilutes the ink with dilution fluid in this way, a problem arises in that irregularities occur in the quantity of ink supplied to the dispensing nozzle 11.

[0017] In other words, the ink I pushed out from the fixed flow nozzle 12 is conveyed along the surface of the nozzle plate 4 and supplied to the dispensing nozzle 11. The quantity of ink supplied to this dispensing nozzle 11 varies according to the interval r of the nozzles, and the wettability (water repellency) of the nozzle plate 4 between the nozzles, etc. The dampness of the nozzle plate 4 may vary, causing fluctuations in printing quality during dot printing.

[0018] Therefore, irregularities occur during printing of dots in these types of ink jet printers for the above-mentioned reasons and the reproduction of print tones (reproduction of printing concentration) is inadequate.

[0019] Further, the nozzle plate 4 in the dispensing nozzle 11 and the fixed flow nozzle 12 must be finely machined, and irregularities or variations are unavoidable in such type of machining. Therefore, irregularities in the interval r of the nozzles for each head occur in the multihead, making irregularities or variations unavoidable in the quantity of ink flying out from the heads. When irregularities in ink quantity occur in the heads in this way, stripes occur in the dot printing due to the same print tone being produced by each head, so that a drastic decline in print quality occurs.

[0020] In terms of the ink quantity supplied to the dispensing nozzle 11 to print one print tone, the thinner the printing concentration (the weaker the printer contrast), or in other words, as less ink is supplied to the dispensing nozzle 11, the effect of irregularities becomes greater. The greater the effect of irregularities, the weaker the reproduction of the print tone becomes, and effects such as stripes become more obvious so that the quality of the printing drastically deteriorates.

SUMMARY OF THE INVENTION

[0021] In view of the above problems with the related art, this invention has the object of providing a printer and printer head control method to reduce irregularities that occur in the related art and deliver high quality printing in the ink quantity supplied to the dispensing nozzle in jet printers that dilute the printing ink with dilution fluid.

[0022] In order to achieve the above objects, the printer and printer control method of this invention according to claim 1 through claim 8, regulates the ink quantity by controlling the number of drive signal pulses.

[0023] To further achieve the above objects, the printer and printer control method of this invention according to claim 1 through claim 8, controls the number of pulses in the drive signal to supply ink droplets with few irregularities or variations so that irregularities in ink quantity due to variations in nozzle interval r and irregularities in ink quantity due to changes in dampness are reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Fig. 1 illustrates signal waveforms showing the drive signal of the piezoelectric element for the ink, in the ink jet printer according to an embodiment of the invention.

[0025] Fig. 2A and Fig. 2B illustrate signal timing waveforms showing the basic waveform of the drive pulses of Fig. 1A through Fig. 1H.

[0026] Fig. 3 is an oblique view showing the movement of the ink according to the basic waveforms of Fig. 2A and Fig. 2B.

[0027] Fig. 4A and Fig. 4B illustrate signal waveforms showing the relation of the dilution fluid drive signal with the drive signals of Fig. 1A through Fig.1H.

[0028] Fig. 5 is a graph showing characteristic curves from results of the drive signals of Fig. 1A through Fig. 1H.

[0029] Fig. 6 is a table showing drive results from the drive signals of Fig. 1A through Fig. 1H compared with the related art.

[0030] Fig. 7 is an elevational view showing the head for the ink jet printer of another embodiment.

[0031] Fig. 8 is a cross sectional view showing an ink jet printer.

[0032] Fig. 9 is an oblique view showing the movement of the ink by the drive method of the related art.

[0033] Fig. 10A and Fig. 10B illustrate signal waveforms showing the drive signal by means of the drive method of the related art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] Hereafter, the embodiments of this invention are described in detail while referring to the accompanying drawings.

[0035] Fig. 2 is a signal timing waveform drawing showing the basic waveforms of the drive signal for driving the ink piezoelectric element 5I in the ink jet printer according to an embodiment of the present invention. The ink piezoelectric element 5I in the ink jet printer of this embodiment is driven by combining these basic pulses and the dilution fluid element 5K is also correspondingly driven.

[0036] In the ink jet printer of this embodiment, except for the different structure of the head controller for these drive signals, the structure is otherwise identical to the ink jet printer 1 described in Fig. 8. Components different

from the structure of Fig. 8 are shown with reference numerals in parentheses in the same figure and the following description utilizes Fig. 8. Descriptions of sections identical to the ink jet printer 1 are omitted.

[0037] The basic waveform, as shown here in Fig. 3, supplies drops of ink I to the dispensing outlet 11A of the dispensing nozzle 11 so that the signal level changes within short time periods, and has a pulse waveform with a fixed amplitude. This basic pulse further has a small drop basic waveform SiS for supplying ink I in small drops, and also a large drop basic waveform SiL for supplying ink I in large drops, in proportion to the small drop basic waveform SiS. A drive signal Si is formed for the piezoelectric element 5I in this embodiment, by combining the small drop basic waveform SiS and the large drop basic waveform SiL, according to the ink supply quantity determined by the print tone. In Fig. 2, the numeral below the waveform indicates the time for each period in microseconds.

[0038] After these basic waveforms SiS and SiL first deliver approximately half of the ink quantity for dispensing outlet 11A to the pressure chamber 8I, the ink I is supplied in drops to the dispensing outlet 11A, and the remaining half of the ink is next supplied to the pressure chamber 8I. Most of the ink from the buffer tank 6I is therefore not supplied all at once, so that irregularities in the quantity of ink drops being supplied can be reduced.

[0039] The signal levels of the basic waveforms SiS and SiL are first raised (for instance in a period of 2 microseconds) so that the volume of the pressure chamber 8I is increased, and afterwards the signal level lowered so that the volume in the pressure chamber 8I can be lowered and the ink I can be pushed out of the fixed flow nozzle 12. Finally, the signal level is raised to the original signal level so that the volume in the pressure chamber 8I can increase.

[0040] After the signal levels of the basic waveforms SiS and SiL are raised, a fixed signal level is maintained for a specified time period (for instance 2 microseconds) until the signal levels start to fall. The residual vibrations in the piezoelectric element can therefore be suppressed over a sufficiently wide actual range in the ink jet printer 21, and ink meniscus variations in the spray hole can be stabilized so that irregularities in the quantity of ink drops being supplied can be reduced.

[0041] Also, after the signal levels of the basic waveforms SiS and SiL are lowered, a fixed signal level is maintained for a specified time period (for instance 2 microseconds) until the signal levels start to rise. In the ink jet printer 21, after the ink I is reliably supplied to the dispensing outlet 11A of dispensing nozzle 11, the voltage of the pressure chamber 8I can be sufficiently stabilized, and the pressure in pressure chamber 8I lowered so that irregularities in the quantity of ink drops being supplied can be reduced.

[0042] The large drop basic waveform SiL is set so that the amplitude becomes larger and the period that the signal level is low becomes larger compared to the small drop basic waveform SiS (for instance 4 microseconds for the small drop basic waveform SiS, and 9 microseconds for the large drop basic waveform SiL), and that large drops of ink I (compared to the small drops) can be supplied.

[0043] In this embodiment, print tone data D1 for eight print tones including a print tone having dots with no ink adhering, are input to the head controller 26. The head controller 26 combines the basic waveforms SiS and SiL and generates the drive signal Si of the piezoelectric element 5I according to this print tone data D1 as shown in Fig. 1.

[0044] The head controller 26 in other words, maintains the ink and dilution fluid drive signals Si and Sk at a fixed signal level (Fig. 1A) at a first print tone having dots with no ink adhering. In contrast, in a continuing second print tone, a piezoelectric element 5I is driven by a drive signal Si2 utilizing only one of the small drop basic waveforms SiS (Fig. 1B). In a third print tone, a piezoelectric element 5I is driven by a drive signal Si3 utilizing only one of the large drop basic waveforms SiL (Fig. 1C).

[0045] In a continuing fourth print tone, a drive signal Si4 (Fig. 1D) is generated by a continuous three small drop basic waveforms SiS, and in a fifth continuing print tone, a drive signal Si5 is generated (Fig. 1E) by a continuous three large drop basic waveforms SiL.

[0046] In a sixth continuing print tone, a drive signal Si6 is generated (Fig. 1F) by a continuous five small drop basic waveforms SiS. In a seventh continuing print tone, a drive signal Si7 is generated (Fig. 1G) by a continuous five small drop basic waveforms SiS. In the eighth print tone having the greatest ink concentration, after a continuous three small drop basic waveforms SiS, a drive signal Si8 is generated (Fig. 1H) per a continuous three large drop basic waveforms SiL.

[0047] In this way, the ink quantity supplied to the dispensing outlet 11A of dispensing nozzle 1 is increased in the head controller 26 according to the print tone.

[0048] In this embodiment, the ink eject printer 21 is configured to regulate the quantity of ink supplied to the dispensing nozzle 11 according to the number of pulses in the drive signal Si. By also at this time, using two pulses having different amplitudes, the quantity of ink is regulated by controlling the amplitude of the pulses, as well as the number of pulses.

[0049] By forming drive signals Si in this way, the head controller 26, after allotting the large drop basic waveforms SiL, maintains the drive signal Si signal level at a fixed signal level for a fixed period T (for instance, 5 microseconds) and then allots the basic waveforms SiS and SiL. Thus, even when the ink I is supplied by repetitive basic waveforms SiS and SiL in this way, the head controller 26 can prevent most of the ink quantity from being supplied from the buffer tank 6I at one time, so that irregularities in the quantity of ink drops being supplied can be reduced.

[0050] Besides generating the ink drive signal Si, the head controller 26, as shown in Fig. 4, gradually raises the signal level of the dilution fluid drive signal Sk , when a time t1 has elapsed (Figs. 4A and 4B) within a specified time (for instance 13 microseconds) from the time point t0 at which the ink I initially starts to be pushed out by the ink drive signal Si. The head controller 26 in this way supplies the ink I to the dispensing outlet 11A of dispensing nozzle 11 (see reference symbol B of Fig. 8), while pulling the meniscus of the ink I into the pressure chamber 8K through the dispensing nozzle 11, so that the ink I will not spill in dispensing outlet 11A of dispensing nozzle 11. Further, the dilution fluid K from the buffer tank 6K is fed beforehand, effectively utilizing the time period that ink I is supplied to the dispensing outlet 11A of dispensing nozzle 11.

[0051] When a sufficient amount of time (in this embodiment, a time t2 at which 140 microseconds has elapsed from time point t0) for the head controller 26 to supply the ink I by utilizing the basic pulses has elapsed, the rise of the dilution fluid drive signal Sk is stopped, and after holding the drive signal Sk signal level at a fixed value for a specified period (for example, 10 microseconds), the signal level is lowered and the dilution fluid K emitted. The head controller 26 in this way, along with diluting the ink I supplied from the dispensing outlet 11A by utilizing the dilution fluid K, causes the diluted ink to fly towards the object for printing.

[0052] The head controller 26 is configured to print by increasing the concentration of ink according to the print tone. Along with the ink I and concentration, the amount of consumed dilution fluid K, and the total amount of ink and dilution fluid consumed are shown in Fig. 5. Irregularities were measured by utilizing the 32 dispensing nozzle and as shown in Fig. 6, a remarkable reduction in irregularities was verified compared to the related art. Fig. 6 shows results from measuring the second print tone of the signal pulse of Fig. 1B.

[0053] Further in this embodiment, the ink piezoelectric element 5I, the oscillator plate 3, the pressure chamber 8I and the head controller 26 comprise the ink supply device for supplying the ink A at an ink quantity determined by the print tone, to the dispensing outlet 11A of dispensing nozzle 11. Also in this embodiment, the ink piezoelectric element 5K, the oscillator plate 3, the pressure chamber 8K and the head controller 26 comprise the dilution fluid drive device for making the ink I diluted by the dilution fluid K, fly towards the object for printing.

[0054] When the ink I tank in the ink jet printer 21 (Fig. 8) is filled, the ink I supplied from this tank by way of the supply path LI, is stored in the buffer tank 6I and also supplied to the pressure chamber 8I. In the same way, when the dilution fluid K tank is filled, the dilution fluid K is supplied from this tank by way of the supply path LK, is stored in the buffer tank 6I and also supplied to the pressure chamber 8K.

[0055] When printing starts in the ink jet printer 21 set in this way, a head 22 supported to face towards the object for printing, repetitively scans along the surface of the object for printing. Ink I is supplied from the fixed flow nozzle 12 to the dispensing outlet 11A of dispensing nozzle 11 in the head 22 of the ink jet printer at this time, and the ink I is diluted by the dilution fluid K supplied from the dispensing nozzle 11. This diluted ink I is further made to fly along with the dilution fluid K, towards the object for printing. In this way, printing tasks such as making the ink I adhere in sequential dot shapes in the desired characters on the object for printing are performed.

[0056] In the head 22, to print a dot at this time, the ink piezoelectric element 5I is repetitively driven by the basic waveforms SiS and SiL, according to print tone data D1 input to the head controller 26. Therefore, in the head 22, the ink I stored in the buffer tank 6I is supplied at intervals to the pressure chamber 8I by way of the supply path 7I. Also, the ink I held in the pressure chamber 8I is supplied at intervals to the dispensing outlet 11A of dispensing nozzle 11 by way of the fixed flow nozzle 12.

[0057] The head 22 at this time, varies the signal level within a short period, and also varies the volume within chamber 8I by repetitively driving the ink piezoelectric element 5I with basic waveforms SiS and SiL constituted by pulses of a fixed amplitude, so that the ink I is supplied in drops to the dispensing outlet 11 A of dispensing nozzle 11. The irregularities in the ink I can in this way, be remarkably reduced compared to the method of the related art for collecting and supplying the required amount of ink. In other words, supplying the ink in drops reduces by a corresponding amount, the contact surface of the ink with the surface of the nozzle plate 4, compared to the method for collecting and supplying the required amount of ink all at one time, so that irregularities in the quantity of ink due to variations in the dampness of the nozzle plate 4 can be reduced. The print tones can therefore be reproduced with better quality (See Fig. 6).

[0058] Also, after these types of ink drops are sent from the fixed flow nozzle 12, the drops are separated from the remaining ink I in the fixed flow nozzle 12 and moved to the dispensing nozzle 11 by the movement energy imparted when sent. In contrast, in the method of the related art for collecting and sending the required amount all at one time, the ink I from the spray hole 12a of the fixed flow nozzle 12 elongates in a belt shape and is supplied to the dispensing outlet 11A of dispensing nozzle 11. This ink I is supplied to the dispensing nozzle 11 not only by the movement energy when sent from the fixed flow nozzle 12, but also by suction force of the dispensing outlet 11A (for instance, the capillary action phenomenon of dispensing nozzle 11) etc.

[0059] In this way, compared to the related art, irregularities in the quantity of ink can be remarkably reduced in this embodiment, even when variations or irregularities are present in the distance r between the dispensing nozzle 11 and the fixed flow nozzle 12, and stripes/noise

occurring from solid printing with multiheads in a printer due to irregularities in the ink quantity of each head can be prevented.

[0060] Further, a remarkable improvement in printing quality can thus be obtained in this embodiment compared to the related art.

[0061] Also in this embodiment, rather than just one basic pulse, a large drop basic waveform SiL to make large changes in the signal level, and a small drop basic waveform SiS to make comparatively small changes in the signal level, are both combined together to drive the ink piezoelectric element 5I. The ink jet printer 21 can in this way express many print tones with a small number of pulses compared to the case of just repetitively issuing one basic pulse. The time required to supply the ink I is therefore shortened by a corresponding amount, and the time required to print one dot can therefore be shortened.

[0062] After raising the amplitude of the signal level approximately one-half in the basic pulse, by lowering the signal level to emit the ink, and next raising the amplitude approximately one-half, restoring the signal level to the original signal level, the residual oscillation in the piezoelectric element can be suppressed, and changes in the meniscus can be stabilized. Further, changes in the meniscus can also be stabilized by providing a fixed period repeating the basic pulse. Irregularities in the ink quantity of the drops can in this way be reduced and consequently irregularities in the quantity of the ink diluted by the dilution fluid can also be reduced.

[0063] By also maintaining the signal level of the drive signal at a fixed signal level, within a fixed period between the period with the rise in signal level, and the period of the lowering of the signal level, changes in the volume of the pressure chamber 81 can be stabilized within a sufficient range. Irregularities in the ink quantity of the drops are thus reduced and as a result, irregularities in the quantity of the ink diluted by the dilution fluid can also be reduced.

[0064] However, when the ink I is supplied at intervals from the fixed flow nozzle 12, much time is required for supplying ink I to the dispensing nozzle 11 compared to the method of the related art. Therefore, just as in the related art, after ink I is supplied to the dispensing nozzle 11 and driven to the dispensing nozzle 11 side (See Fig. 10), the period for attachment of ink droplets to the paper becomes longer by a corresponding amount, and time is therefore required for continuous printing of dots. Therefore, in the ink jet printer 21, while continuously supplying ink I at intervals from the fixed flow nozzle 12, preparations are made for emitting the dilution fluid K from the dispensing nozzle 11 in the period that the ink I is supplied to the dispensing nozzle 11, by driving (Fig. 4B) the piezoelectric element 5K from the time point t1 to the time point t2, to increase the volume of the pressure chamber 8K on the dispensing nozzle 11 side. Further, when the supply of ink I to the dispensing nozzle 11 is finished, the dilution fluid K is emitted in the final 10 microseconds of a specified period (Fig. 4B) and the ink droplets are made to fly out to the paper.

[0065] Also, by driving the piezoelectric element 5K so that the volume on the dispensing nozzle 11 side of the pressure chamber 8K becomes larger, while supplying ink I from the fixed flow nozzle 12, the ink I supplied to the dispensing outlet 11A of dispensing nozzle 11 is suctioned into the vacuum chamber 8K without collecting as drops in the dispensing outlet 11A. By repetitively supplying the ink I to the dispensing nozzle 11 in this way, the ink drops can be moved from the fixed flow nozzle 12 to the dispensing nozzle 11 under the same conditions as when the supply of ink drops first starts, and irregularities in ink quantity of the small drops and large drops can be decreased.

[0066] In the invention as described above, the quantity of ink supplied to the dispensing outlet 11A of dispensing nozzle 11 is regulated by controlling the number of pulses in the drive signal so that irregularities in quantity of ink supplied to the dispensing nozzle are reduced, and high quality printing results can be obtained compared to the related art.

[0067] Also, besides the number of pulses, the quantity of ink can be regulated by controlling the amplitude of the pulses so that many print tones can be reproduced with a small number of pulses. The time required to supply the ink I can therefore be reduced by a corresponding amount, and the time required to print one dot can be shortened.

[0068] Further, after the signal level of the drive signal in a direction increasing the volume of the pressure chamber has been changed, by changing the signal level of the drive signal in a direction that reduces the volume of the pressure chamber, and next changing the signal level of the drive signal in a direction increasing the volume of the pressure chamber, the irregularities in the ink quantity of the drops can be decreased, and as a consequence, irregularities in the quantity of the ink diluted by the dilution fluid can be reduced.

[0069] The above embodiment described an example having one fixed flow nozzle installed for one dispensing nozzle. However, this invention is not limited to this example, and as shown in Fig. 7, a plurality of fixed flow nozzles may be installed for one dispensing nozzle. In such a case, yellow, cyan or magenta ink may be allotted for instance to each fixed flow nozzle to constitute a color printer mechanism. Instead of this color printer mechanism, the same color may be allotted to each nozzle to significantly shorten the time required for ink supply. Also, the diameter of each nozzle may be varied so that print tones can be reproduced with even higher precision. A combination of the above schemes may also be implemented.

[0070] In the above embodiment an example was described for driving the piezoelectric elements with a combination of two basic pulses. However, this invention is not limited to this example, and the piezoelectric elements may be driven by just one basic pulse as re-

quired, or the piezoelectric element may be driven by a combination of three or more basic pulses.

[0071] In the above embodiment an example was also described for respective ink quantities of approximately one-half before and after emitting the ink from the buffer tank and supplying it to the pressure chamber. However, this invention is not limited to this example, and ink may be collectively supplied to the pressure chamber when irregularities in the quantity of ink can be sufficiently reduced.

[0072] In the above embodiment, an example was also described for maintaining the drive signal at a fixed signal level for a specified period when switching the signal level of the drive signal. However, this invention is not limited to this example, and maintaining the drive level at a fixed signal level may be omitted when irregularities in the quantity of ink can be sufficiently reduced.

[0073] Also in the above embodiment, the dilution fluid was supplied from the buffer tank to the pressure chamber utilizing the period that ink was supplied to the dispensing outlet of the dispensing nozzle. However, this invention is not limited to this example, and after the dilution fluid is emitted, it may be supplied from the buffer tank to the pressure chamber, when a sufficient printing time can be maintained.

[0074] Further in the above embodiment, the emitting of ink and dilution fluid from the nozzle by driving the piezoelectric element was described. However, this invention is not limited to this example, and a wide variety of methods such as thermal methods to locally heat this type of fluid and make air bubbles, and then emit this type of fluid by employing these air bubbles, or emitting the ink (or fluid) by various kinds of drive elements may be employed.

Claims

1. A printer regulating the quantity of ink diluted with a specified dilution fluid and expressing print tones, comprising:

   a drive device to emit said dilution fluid from a dispensing outlet and dilute said ink supplied from said dispensing outlet with said dilution fluid and to also make said ink diluted with said dilution fluid fly towards the object for printing; and
   an ink supply device to supply to said dispensing outlet, a quantity of ink according to said print tone, and

   wherein said ink supply device has a drive element driven by a drive signal having a specified number of pulses.

2. A printer according to claim 1, wherein said ink supply device has:

   a pressure chamber for holding said ink; and
   a fixed flow nozzle extending towards said dispensing outlet from said pressure chamber,

   wherein said drive element is a piezoelectric element for varying the volume of said pressure chamber according to said drive signal.

3. A printer according to claim 1 or 2, wherein said ink supply device regulates the quantity of said ink by controlling the number of said pulses and the amplitude of said pulses.

4. A printer according to claim 3, wherein, in the signal waveform of said printer, after the signal level changes in a direction increasing the volume of said pressure chamber, the signal level changes in a direction decreasing the volume of said pressure chamber, and the signal level next changes in a direction increasing the volume of said pressure chamber.

5. A printer according to any one of claims 1 to 4, wherein said ink supply device has a plurality of ink supply holes adjacent to said dispensing outlets, and said ink is supplied from the ink supply holes to said dispensing outlets.

6. A printer head control method for regulating the quantity of ink diluted with a specified dilution fluid and expressing print tones, wherein said printer head control method drives a drive element by means of drive signal having a specified number of pulses and supplies to a specified dispensing outlet a quantity of ink according to said print tone, and along with diluting said ink supplied from said dispensing outlet with said dilution fluid by emitting said dilution fluid from said dispensing outlet, also makes said diluted ink fly towards the object for printing.

7. A printer head control method according to claim 6, wherein said drive element is a piezoelectric element.

8. A printer head control method according to claim 6 or 7, wherein said method has a plurality of ink supply holes adjacent to said dispensing outlets, and said ink is supplied from the ink supply holes to said dispensing outlets.

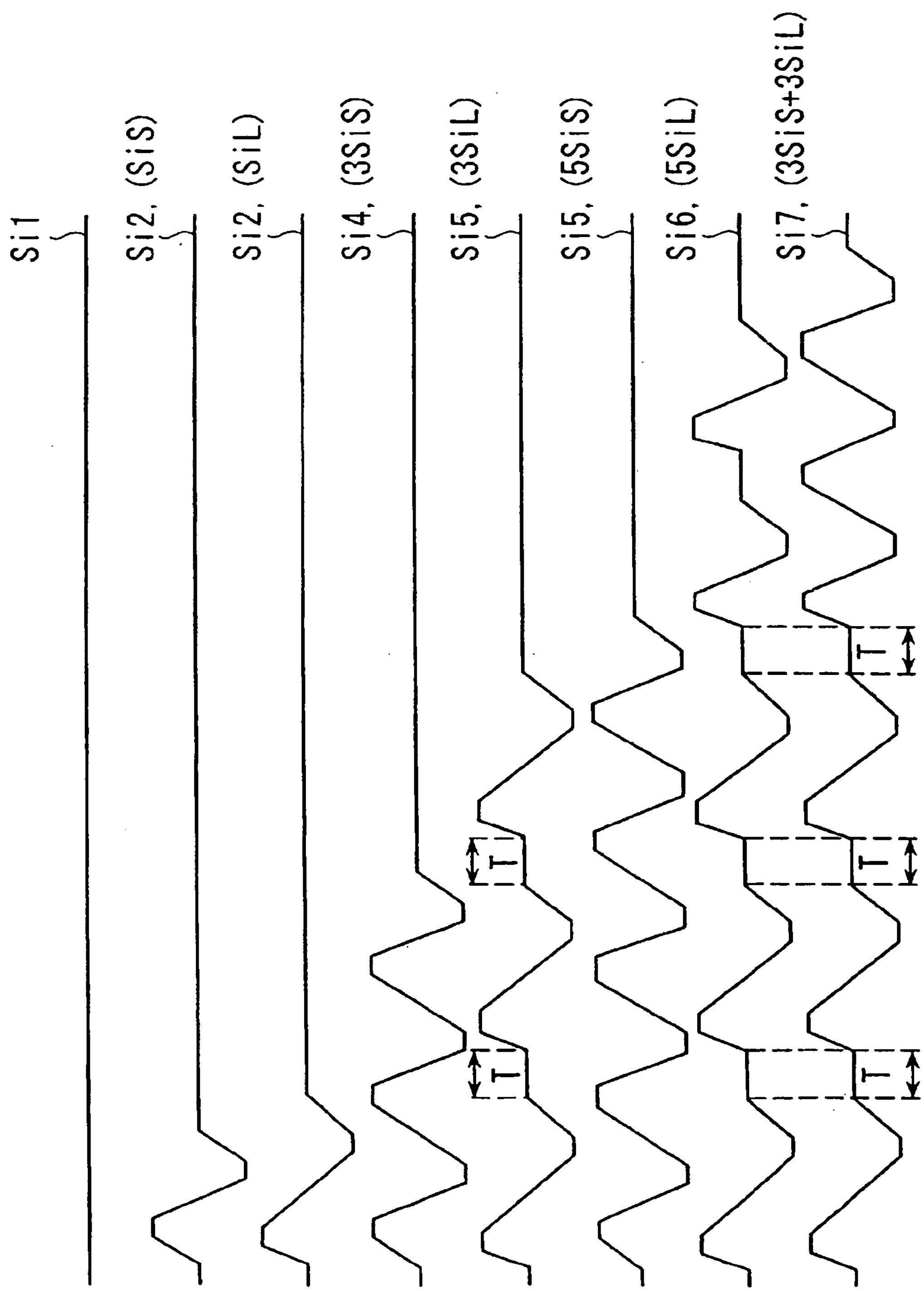


FIG. 1A
FIG. 1B
FIG. 1C
FIG. 1D
FIG. 1E
FIG. 1F
FIG. 1G
FIG. 1H

FIG. 2A

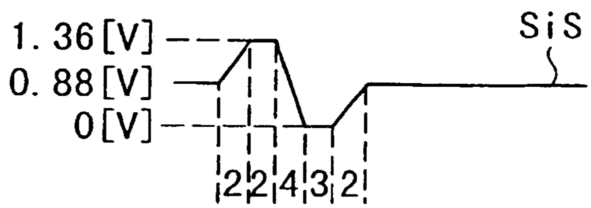


FIG. 2B

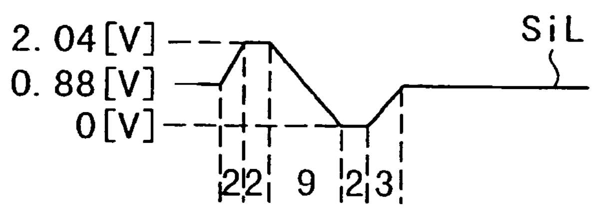


FIG. 3

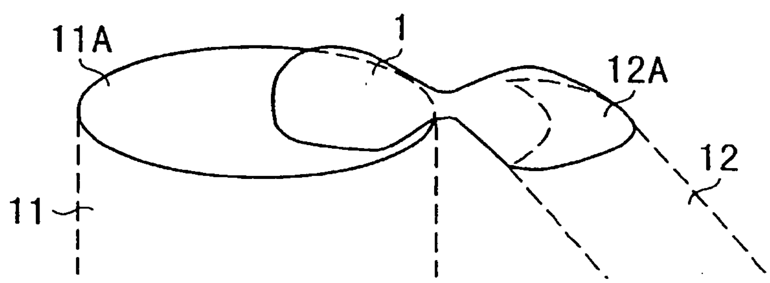


FIG. 4A

FIG. 4B

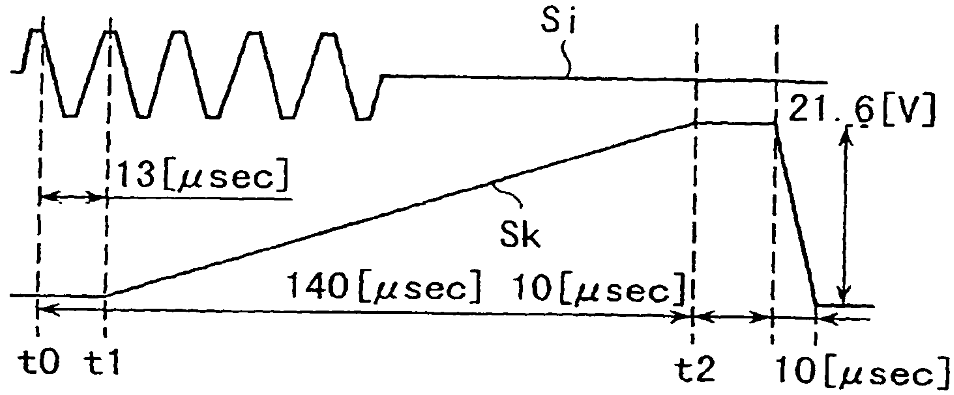


FIG. 5

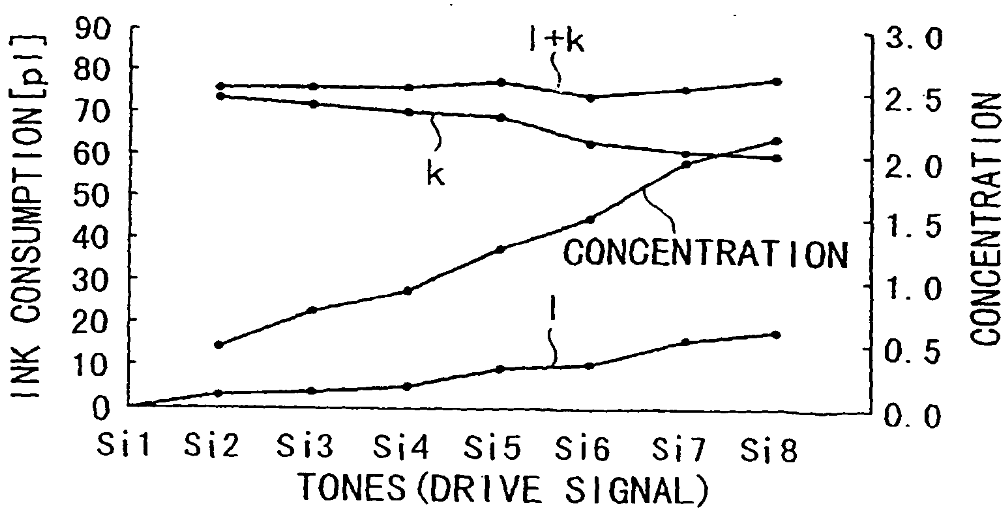


FIG. 6

	RELATED METHOD	EMBODIMENT
AVERAGE INK SUPPLY[pl]	9.29	5.34
MAXIMUM VARIATION[pl]	1.53	0.27
MAXIMUM VARIATION RATIO[%]	16.5	5.1

FIG. 7

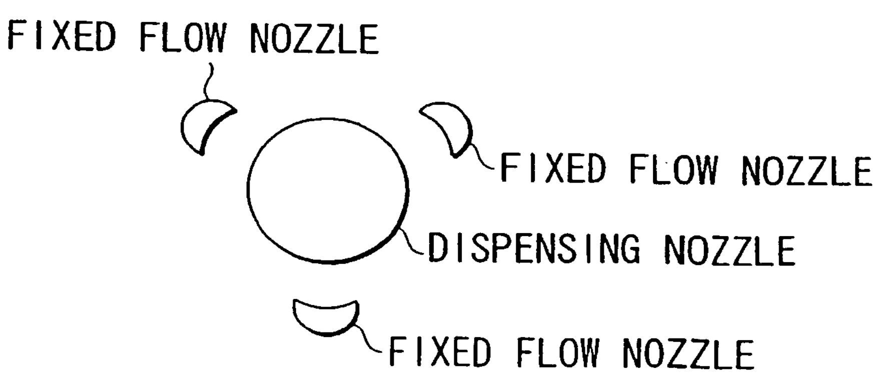


FIG. 8

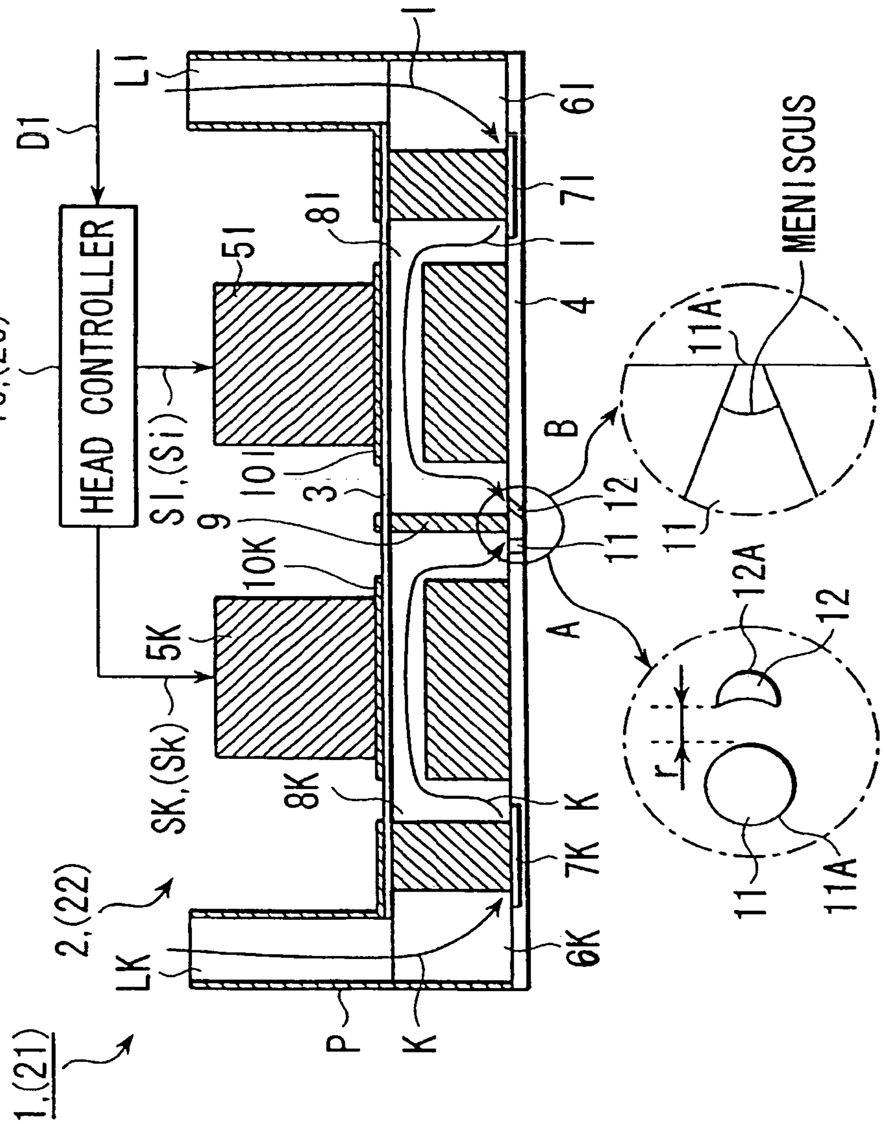

HEAD CONTROLLER
MENISCUS
16,(26)
D1
SK,(Sk)
SI,(Si)
1,(21)
2,(22)
LK
LI
5K
5I
8K
8I
10K
10I
9
3
4
6K
6I
7K
7I
K
I
P
A
B
11
12
11A
12A
r

FIG. 9

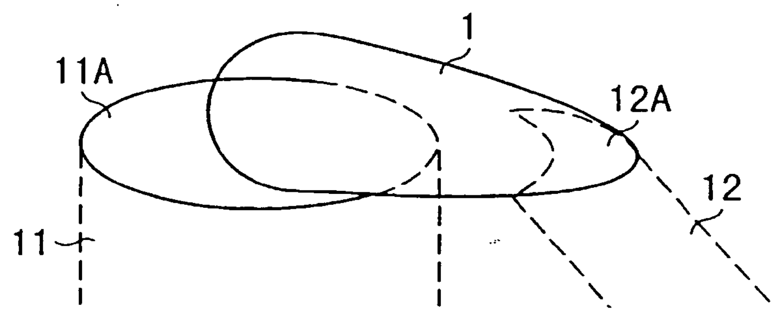


FIG. 10A

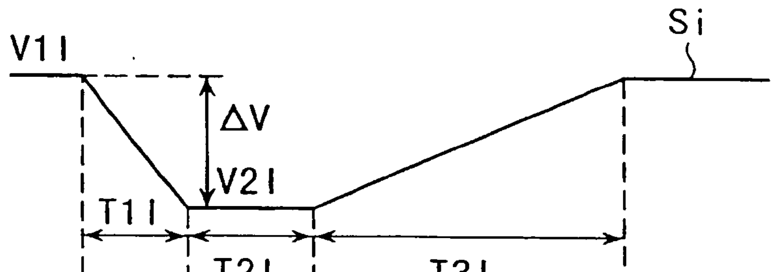
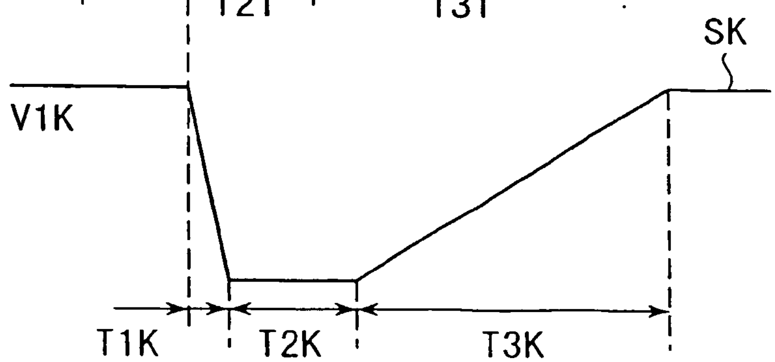


FIG. 10B



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EUROPEAN SEARCH REPORT

Application Number
EP 00 40 2912

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			B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 December 2000	De Groot, R

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